PRELIMINARY

# INSTRUCTION MANUAL

## FOR

## REGULATED POWER SUPPLY

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MODEL LM 237

THIS MANUAL APPLIES TO UNITS

BEARING SERIAL NO. PREFIX A

MP MASTER
MA28751

LAMBDA ELECTRONICS CORP.

# SPECIFICATIONS AND FEATURES

DC OUTPUT--Voltage regulated for line and load

Voltage Range.....22-32 volts DC

Multi-Current Ranges...Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range, with input frequency 55-65 cps. For input frequencies 45-55 or 360-440 cps, derate current ratings 10%.

| Ambient Temperature.. | 40°C | 50°C | 60°C | 71°C |
|---|---|---|---|---|
| Maximum Current..... | 5.0A | 4.4A | 3.9A | 3.1A |

REGULATED VOLTAGE OUTPUT

Regulation (line).....Less than 0.05 percent plus 4.0 millivolts for input variations from 105-132 or 132-105 volts AC

Regulation (load).....Less than 0.03 percent plus 3.0 millivolts for load variations from 0 to full load or full load to 0

Remote Programming

External Resistor....Nominal 200 ohms/volt output

Programming Voltage..One-to-one voltage change

Ripple and Noise.....One millivolt rms; 3 millivolts peak-to-peak

Temperature Coefficient..Change in output voltage less than 0.03%/°C

AC INPUT--105-132 volts AC at 45-440 cps; 300 watts*
*With output loaded to full 40°C rating and input voltage 132 volts at 55-65 cps.

INPUT FUSE--"SLO-BLO" fuse F1 protects the AC input circuit and is rated at 6.25 amperes. Overload of the supply does not cause fuse failure.

OVERLOAD PROTECTION

Thermal.....Thermostat resets automatically when overtemperature condition is eliminated

Electrical.....Within rated voltage range, an automatic electronic current-limiting circuit limits output current to 110 percent of 40°C rated current for protection of load and power supply; for overloads approaching short circuit, both voltage and current decrease until at short circuit, current is 30 percent or less of rated current.

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal block on rear of chassis

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from 0°C to 71°C ambient with corresponding load current ratings for all modes of operation, and all mounting positions.

STORAGE TEMPERATURE-- -55°C to +85°C

CONTROLS
DC output control.....Voltage adjust control permits adjustment of DC output voltage via access hole located in nameplate

REMOTE SENSING--Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation

SPECIFICATIONS AND FEATURES (Cont'd)

PHYSICAL DATA

Size.....4-15/16"H x 7-1/2"W x 9-3/8"D

Weight.....30 lbs. net; 34 lbs. shipping wt.

Finish.....Grey, FED STD 595 No. 26081

MOUNTING--Three surfaces, each with tapped mounting holes, can be utilized for mounting this unit. Refer to figure 9 for mounting details.

## THEORY OF OPERATION

GENERAL

The Lambda power supply circuitry consists of an AC input circuit and transformer; a bias supply consisting of an auxiliary rectifier, filter, and a zener diode regulator; and a main regulator circuit consisting of the main rectifier and filter, a series regulator, emitter follower drivers, an error amplifier, a current limit amplifier, a current sink, an output voltage sensing circuit and an output current sensing circuit.

The circuit arrangement is shown in block diagram form in figure 7. The circuitry is discussed with reference to the block diagram and the schematic diagram.

FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing thermostat S1, which protects the supply against overheating.

The main rectifier, a full-wave bridge rectifier comprised of diodes CR8-CR11, provides the power which is filtered by capacitor C8 and then regulated via a series regulator and delivered to the output. Bias supply, half-wave, auxiliary rectifier CR7, provides voltage filtered by capacitor C7 and regulated by zener diode CR6 for current limit amplifier Q3 and error amplifier Q1, Q2. Zener diode CR1 and resistor R5, across the bias supply, provide a regulated temperature compensated reference voltage. Resistor R4 compensates for input voltage variations.

Operation of the voltage regulator circuit is determined by changes in the output voltage. A change in the output voltage is sensed by sensing divider R1, R2, R3 which compares output voltage with the reference voltage. This provides an error voltage at junction of R2 and R3 which is amplified by error amplifier Q1, and Q2, and is current amplified by drivers Q5, Q6. The amplified signal from drivers Q5, Q6 controls the voltage across series regulator Q8-Q13, which functions as the active regulating element, restoring output voltage to the proper level.

Current limit circuit operation is determined by changes in the load. Current limit amplifier Q3 samples load current through current sensing resistor R25. When the voltage drop across R25 increases compared with the preset regulated voltage reference determined by R17, R18, CR4 and Q4, Q3 conducts. Thus, when the output current rating of the unit is exceeded, current limit amplifier Q3 conducts, decreasing the current through drivers Q5, Q6, resulting in an increase of voltage across the series regulator and a decrease of the output voltage, effectively limiting the output current to a safe value. The current limit value is determined by the factory setting of current limit potentiometer R17.

When operating conditions approach short circuit, and output voltage value decreases below the minimum voltage rating, current sink Q4 saturates and the divider R17, R18, Q4, R19 becomes purely resistive with no regulated reference for current limit operation. With Q4 at saturation the voltage reference becomes proportional to the output voltage, i. e., decreases as the output voltage decreases. This permits Q3 to turn on at lower and lower load currents until output voltage decreases to zero and current decreases to a predetermined low value.

# OPERATING INSTRUCTIONS

## BASIC MODE OF OPERATION

This power supply operates as a constant voltage source provided the load current does not exceed the rated value at 40°C. For continuous operation, load current must not exceed the rating for each ambient temperature. When load current exceeds 110% of 40°C rating, both voltage and current decrease until voltage reaches zero and the current at short circuit equals 30 percent or less of the rated current.

## MOUNTING

When using this unit as a mounted component, a cutout must be provided to permit free-flow of air through the unit. See figure 9 for cutout sizes and specific mounting details.

## CONNECTIONS FOR OPERATION

NOTE: Make all connections to the unit before applying AC input power.

Ground Connections. The Lambda power supply can be operated either with negative or positive output terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. Apply input power to terminals 1 and 2; always connect the ungrounded (hot) lead to terminal 1.

The supply positive terminal is brought out to terminal 6; the negative terminal to terminal 4.

NOTE: When shipped from the factory, the supply is ready for use as a local-sensing constant voltage source. Jumpers are connected at the factory as shown in figure 3. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

Supply-Load Connections. The regulation of the supply at the load may change when connecting leads to practical length are used. To minimize the effect of the output load leads, remote sensing is used. Refer to figure 1 to determine voltage drop for particular cable lengths, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 2.

Local-Sensing Connection, See Figure 3.

Remote-Sensing Connection, See Figure 4.

Programmed Voltage Connection Using External Resistor, See Figure 5. Discrete voltage steps can be programmed with a resistance voltage divider valued at nominal 200 ohms/volt output and a shorting-type switch. For continuous voltage variations, use a variable resistor with the same ohms/volt ratio in place of the voltage divider and shorting-type switch. Use low temperature coefficient resistor(s) to assure most stable operation.

Programmed Voltage Connection Using Programming Voltage, See Figure 6. The power supply voltage output can be programmed with an externally connected programming power supply. The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

The programming supply must have a reverse current capability of 6 ma. minimum.

Alternatively, when supplies with less than 6 ma. reverse current capability are used, a resistor capable of drawing 6 ma. at the minimum programming voltage must be connected across the output terminals of the supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

Operation After Thermostat Shutdown. The thermostat opens the input circuit only when the temperature of the transformer exceeds a maximum safe value. Eliminate the cause(s) for overheating and allow time for the power supply to cool to a proper temperature. When the temperature of the transformer decreases to a safe operating value, the thermostat will reset automatically.

# MAINTENANCE

## GENERAL

This section describes trouble analysis routine, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on specifications and features for the minimum performance standards.

## TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumpers and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 7, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal no load operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

## CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an in-circuit transistor checker. If no checker is available, transistors can be checked with an ohmmeter that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never ZERO; backward resistance is always higher than the forward resistance.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional faulty components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers or a commercial heat sink device placed between the component and the solder joint.

> NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

## PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to measuring instrument.

3. Always use a heat sink when soldering transistors; a transistor pad with mounting feet is an effective heat sink.

MAINTENANCE (Cont'd)

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board never pry or force loose the part; unsolder the component by using the wicking process described below:

(a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or No. 16 stranded wire with 1/2 inch insulation removed.
(b) Dip the wick in liquid rosin flux.
(c) Place the wick onto the soldered connection and apply soldering iron onto the wick.
(d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.
(b) Either positive or negative terminal is connected to chassis ground.
(c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

TROUBLE CHART

| Symptom | Probable Cause | Remedy |
|---|---|---|
| 1. No output voltage | No power input, thermostat S1 open | Check power source, S1, line cord and line cord plug; shut off unit, allow to cool and check ambient temperature |
| | Improper output terminal connection | Refer to appropriate connection diagram, and check for correct connections |
| | Faulty Q2, CR1, CR6 | Check Q2, CR1, CR6 for short and replace as required |
| 2. Unable to adjust output voltage | Damaged VOLTAGE ADJUST control | Check R1 for shorts and/or open; replace as required |
| | Supply operating as constant current source at current limit value | Remove load, check load value and check for shorts and/or improper supply-load connections; refer to appropriate diagram for correct connections |
| 3. Output voltage too high | Improper output terminal connection | Refer to appropriate connection diagram, and check for correct connections |
| | Faulty Q1, R1, Q8-Q13, Q5, Q6, or CR1 | Check R1 for open; Q8-Q13, Q5, Q6, Q1 for short; CR1 for open and replace as required |
| 4. Output voltage too low | Load resistance improper for unit ratings | Check load resistance value |

## TROUBLE CHART (Cont'd)

| Symptom | Probable Cause | Remedy |
|---|---|---|
| 4. (Cont'd) | Faulty CR4, Q2, Q3, R25, or R17 | Check CR4, Q2, Q3 for short, R25, R17 for open, replace as required |
| 5. High ripple and unregulated DC output | Load resistance improper for unit ratings | Check load resistance value |
| 6. Current limit value improper and varies directly with output voltage | Faulty Q4 | Check Q4 for short and replace as required |
| 7. High ripple | Improper ground | Connect terminal 6 or terminal 4 to ground terminal 5 |

## PERFORMANCE CHECK

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 8. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC VTVM (John Fluke Model 825A or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the full load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power supply line regulation accuracy on the VTVM differential meter.

Use a VTVM, Ballantine 320 or equivalent, to measure rms ripple voltage of the power supply DC output. Use oscilloscope to measure peak-to-peak ripple voltage of the power supply DC output.

## ADJUSTMENT OF CALIBRATION CONTROL R17

Whenever Q3, Q4, CR4, R25 or R17 are replaced, and voltage and current indications do not reflect maximum ratings, adjust R17 as follows:

1. Remove AC power input to the supply.
2. Unsolder wiper of R17 from resistor housing and turn to full CW position.
3. Operate power supply for constant voltage with local sensing, connected as shown in figure 3, with no external load.
4. Turn voltage adjust control until minimum rated output voltage is obtained.
5. Apply load so that output current is 110% of 40°C rating for the unit.
6. Using an oscilloscope, Tektronix 503 or equivalent, observe output voltage while adjusting R17 in a CCW direction. Adjust R17 until output ripple increases sharply and oscilloscope pattern changes.
7. After adjustment is completed, remove AC power input to the supply and solder wiper of R17 to resistor housing.
8. After soldering, check setting and repeat adjustment procedure if required.

## SERVICE

When additional instructions are required or repair service is desired, contact the nearest office of the Lambda Electronics Corp. where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

## PARTS ORDERING

Standard components and special components used in Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

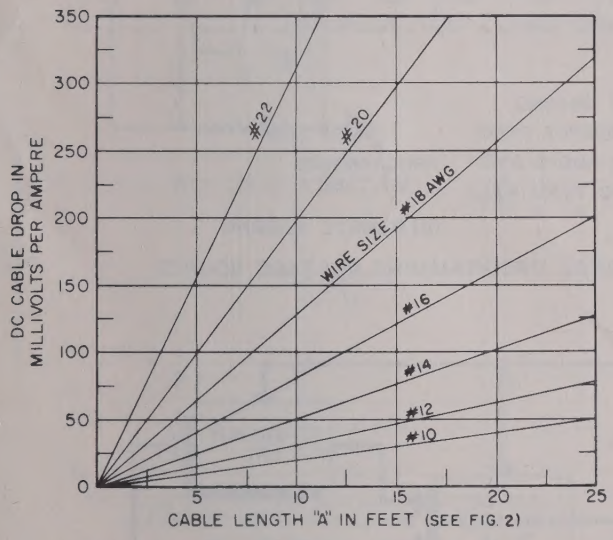



FIGURE 1. CABLE CONNECTION CHART

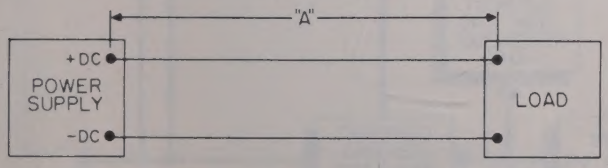
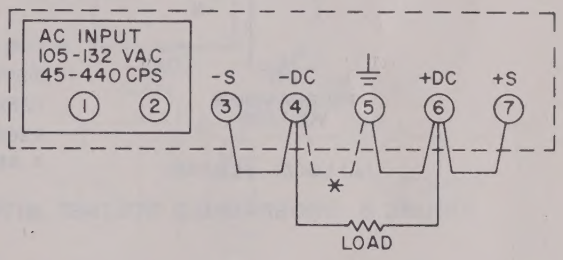
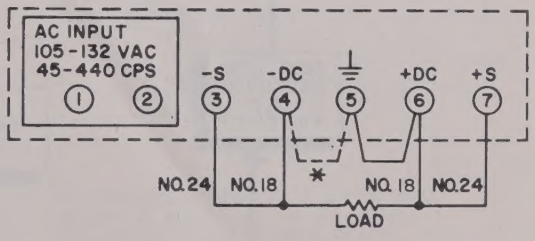



FIGURE 2. CABLE LENGTH "A" IN FEET




NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 3. LOCAL SENSING CONNECTIONS




NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 4. REMOTE SENSING CONNECTIONS

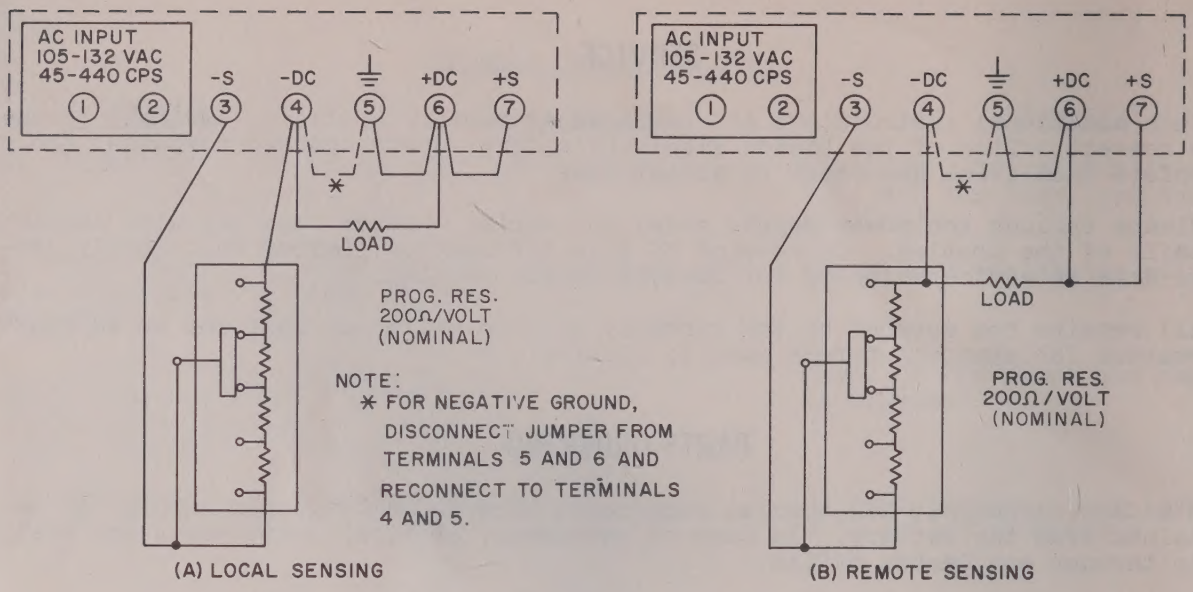



FIGURE 5. PROGRAMMED VOLTAGE, WITH EXTERNAL RESISTOR

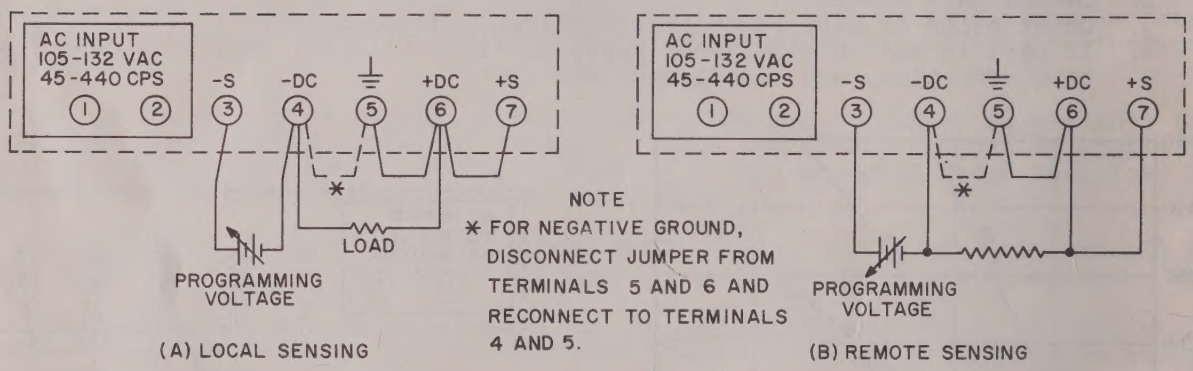



FIGURE 6. PROGRAMMED VOLTAGE, WITH EXTERNAL PROGRAMMING VOLTAGE SOURCE

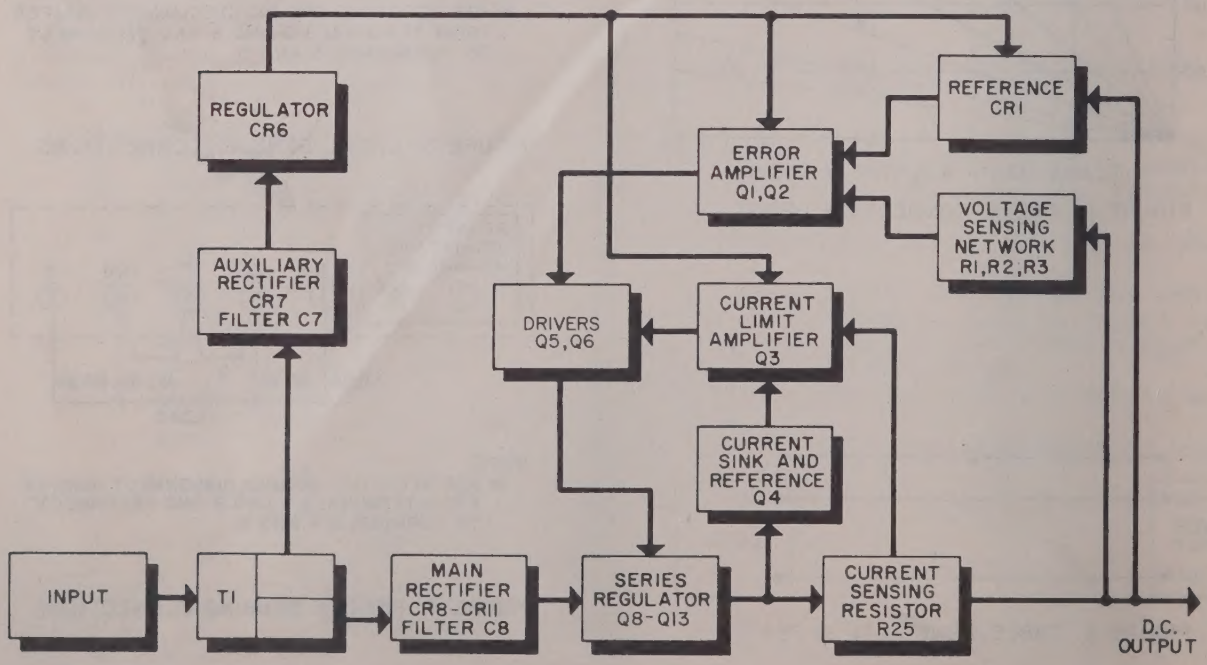
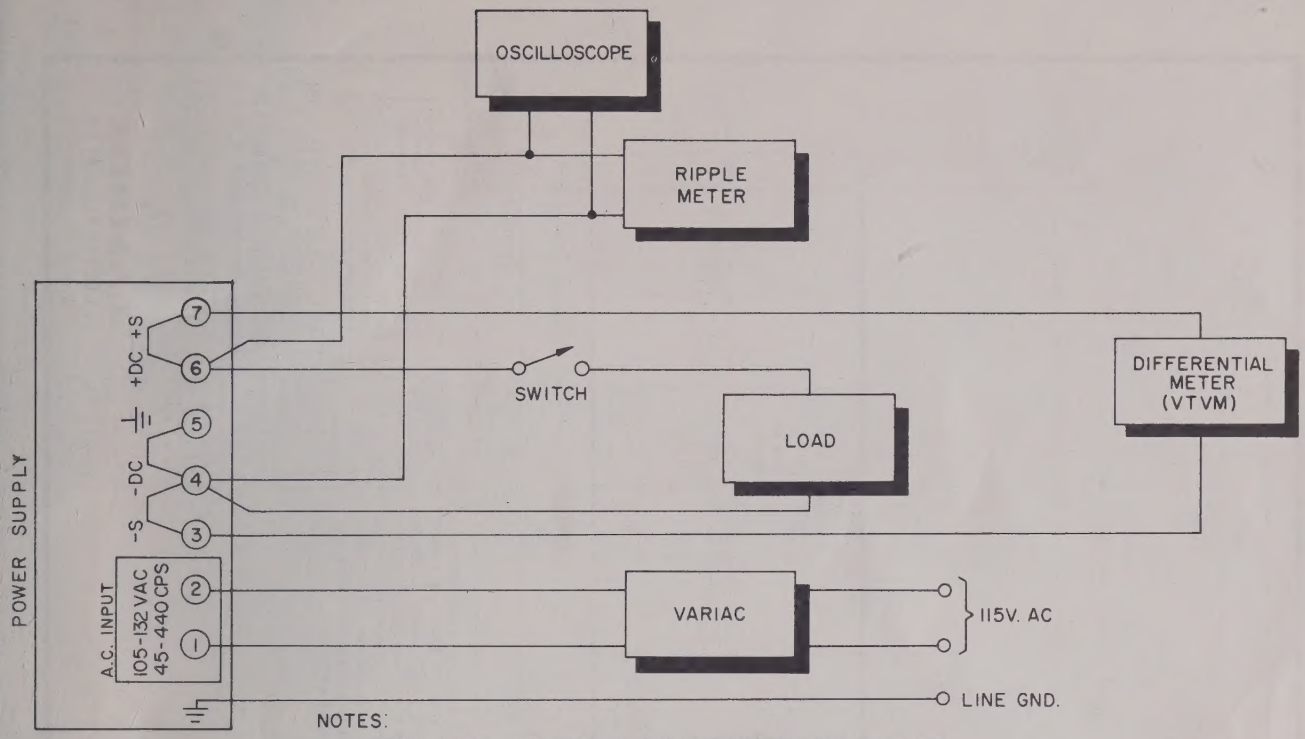


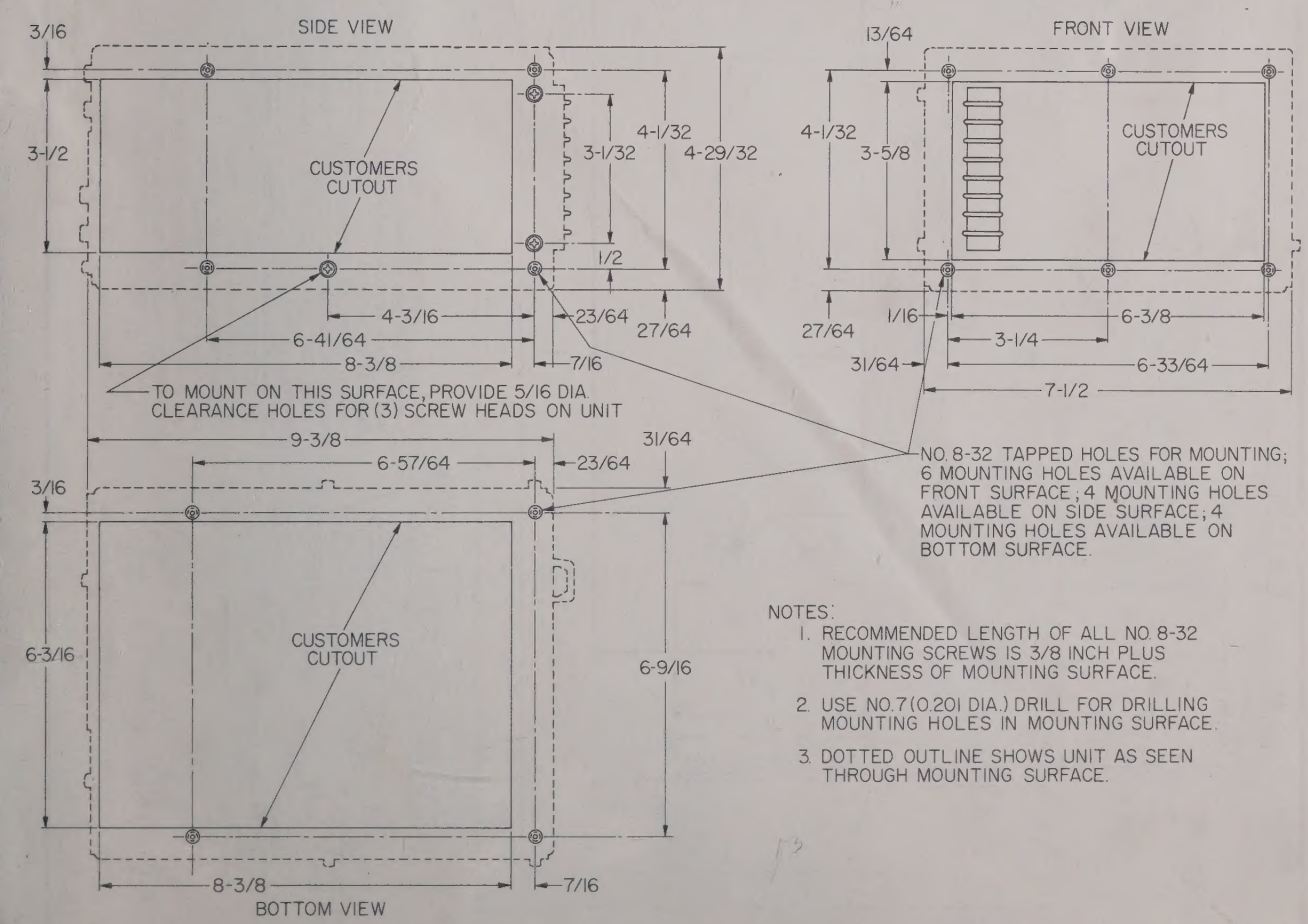

FIGURE 7. BLOCK DIAGRAM




NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

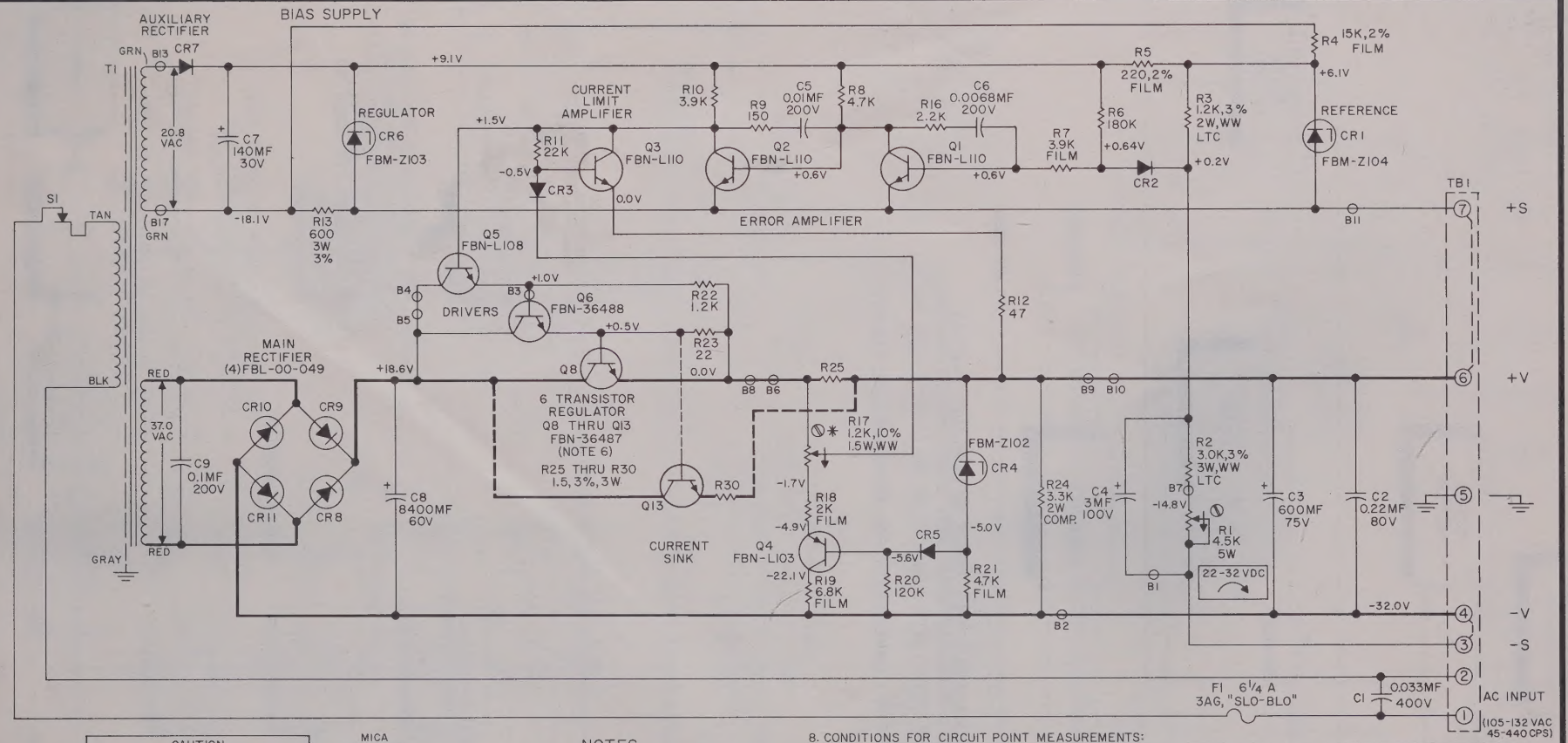
FIGURE 8. TEST CONNECTIONS FOR PERFORMANCE CHECKS

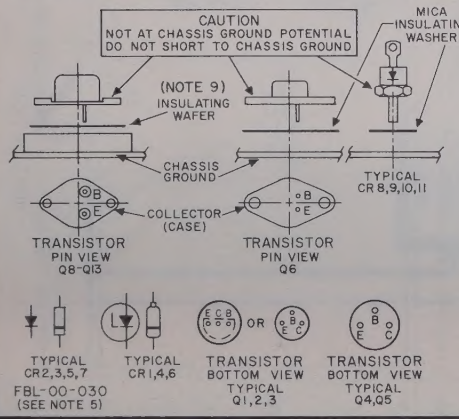



NOTES:

1. RECOMMENDED LENGTH OF ALL NO. 8-32 MOUNTING SCREWS IS 3/8 INCH PLUS THICKNESS OF MOUNTING SURFACE.
2. USE NO. 7 (0.201 DIA.) DRILL FOR DRILLING MOUNTING HOLES IN MOUNTING SURFACE.
3. DOTTED OUTLINE SHOWS UNIT AS SEEN THROUGH MOUNTING SURFACE.

FIGURE 9. RECOMMENDED MOUNTING CUTOUTS




## NOTES

1. RESISTOR VALUES ARE IN OHMS.
2. RESISTOR WATTAGE 1/2 WATT; RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: COMP. ±10%; WIREWOUND ±5%; FILM ±5%; UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC -10%,+100%; MYLAR ±10%; UNLESS OTHERWISE NOTED.
5. SYMBOLS:
   - INDICATES CLOCKWISE ROTATION OF SHAFT.
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - INDICATES CONNECTION TO CHASSIS.
   - INDICATES ACTUAL UNIT MARKING
   - SEE INSTRUCTION MANUAL.
   - LAMBDA PT. #FBL-00-030; USE IN4002 DIODE FOR REPLACEMENT UNLESS OTHERWISE NOTED.
   - INDICATES TERMINAL ON PRINTED WIRING BOARD "B"
6. DESIGNATIONS ARE LAMBDA PART NUMBERS.
7. DERATE CURRENT 10% FOR 45-55 CPS OR 360-440 CPS.
8. CONDITIONS FOR CIRCUIT POINT MEASUREMENTS: INPUT: 115 VAC, 60 CPS; OUTPUT: 32 VDC, NO LOAD INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED. DC MEASUREMENTS TAKEN WITH 20,000 OHMS/V VOLTMETER BETWEEN +S (TERM. 7) & INDICATED POINTS UNLESS NOTED.
9. COAT BOTH SIDES OF INSULATING WAFER WITH DOW CORNING NO. 340 SILICONE GREASE.

| REFERENCE DESIGNATIONS NOT USED | |
|---|---|
| Q7 | R14 |
| | R15 |

| RATING TABLE | |
|---|---|
| AMB. TEMP. | MAX. LOAD |
| 40°C | 5.0A |
| 50°C | 4.4A |
| 60°C | 3.9A |
| 71°C | 3.1A |

(SEE NOTE 7)

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO SUPPLY-TO-LOAD WIRING DIAGRAMS.

DOTTED CONNECTIONS SHOWN ON TB1 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING CONNECTION.

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A

# SCHEMATIC DIAGRAM

REGULATED POWER SUPPLY

MODEL LM 237, 22-32VDC

LAMBDA ELECTRONICS CORP.
MELVILLE NEW YORK

# 5-Year Guarantee

We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of five years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except tubes and fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.

We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

LAMBDA ELECTRONICS CORP.
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MP MASTER
MA28751